

“A Pace Not Dictated by Electrons”: An Empirical Study of Work Without Email

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ABSTRACT

We report on an empirical study where we cut off email usage for five workdays for 13 information workers in an organization. We employed both quantitative measures such as computer log data and ethnographic methods to compare a baseline condition (normal email usage) with our experimental manipulation (email cutoff). Our results show that without email, people multitasked less and had a longer task focus, as measured by a lower frequency of shifting between windows and a longer duration of time spent working in each computer window. Further, we directly measured stress using wearable heart rate monitors and found that stress, as measured by heart rate variability, was lower without email. Interview data were consistent with our quantitative measures, as participants reported being able to focus more on their tasks. We discuss the implications for managing email better in organizations.

Author Keywords

Email; multitasking; interruptions; empirical study; sensors

ACM Classification Keywords

H.5.3 [Information Interfaces and Presentation (e.g., HCI)]: Group and Organization Interfaces; K.4.m [Computers and Society]: Miscellaneous.

INTRODUCTION

Less than a year ago, a New York Times article drew an analogy between zombies and emails: you keep killing them (or deleting them), and they never stop coming [20]. This tongue-in-cheek commentary brings to light a broader issue associated with being continually connected to ICTs and email in particular—we just can’t seem to keep up. The wide adoption of ICTs in the workplace enables people to stay continually up-to-date and connected with others, but critiques as in the New York Times article raise important questions about how continual connectivity might impact aspects of our psyche and behavior such as creating stress and distraction.

Does being continually connected provide benefits to information workers? Wacjman and Rose [29] claim that being continually connected gives agency to workers; information workers are constantly negotiating how to manage information, when to respond to communications, and how to prioritize tasks and information. Email is currently considered the tool *de rigueur* of the workplace, cf. [3]. However, being continually connected on email has also drawn criticism, expressed by Turkle, who writes “*we don’t do email, our email does us*” [28]. Bolstering this view is a result from a study of email use where 45% of participants associated email with a loss of control [2].

Though we might surmise that we are overburdened with a huge volume of email, how much attention does email demand? Wacjman and Rose [29] found that, on average, information workers engage in more mediated communication each day than face-to-face communication, of which email is the most common. The picture that Jackson et al. [19] found is rather dismal: they found that 70% of emails were attended to within six seconds of arriving. Email may not be distracting if workers quickly returned to their interrupted task; however, it took an average of 64 seconds to resume an interrupted task.

Email is a multi-functional tool in the workplace; not only is it used for communication, but it also serves as a to-do list and personal information management tool [3], for archiving information, as a mechanism to foster coordination and collaboration among colleagues, and as a source for assigning and delegating tasks [30]. Barley et al. [2] summarize this multi-functional character of email by claiming it to be a symbol for work.

In this paper, we address the issues of email and distractions. Whereas email use has been studied through *in situ* observation [3, 25] and surveys [10], we approach email usage from an inverted perspective. We investigate how people perform work in the *absence* of email—a world free of the “zombies” that vex so many in information work.

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CHI12, May 5–10, 2012, Austin, Texas, USA.

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Report Documentation Page			Form Approved OMB No. 0704-0188		
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1. REPORT DATE MAY 2012		2. REPORT TYPE		3. DATES COVERED 00-00-2012 to 00-00-2012	
4. TITLE AND SUBTITLE 'A Pace Not Dictated by Electrons': An Empirical Study of Work Without Email		5a. CONTRACT NUMBER			
		5b. GRANT NUMBER			
		5c. PROGRAM ELEMENT NUMBER			
6. AUTHOR(S)		5d. PROJECT NUMBER			
		5e. TASK NUMBER			
		5f. WORK UNIT NUMBER			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) University of California -Irvine,Department of Informatics,Irvine,CA,92697-3440		8. PERFORMING ORGANIZATION REPORT NUMBER			
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S)			
		11. SPONSOR/MONITOR'S REPORT NUMBER(S)			
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES					
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15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 10	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

EMAIL AND MULTITASKING

Studies of information workers have consistently revealed that they experience high levels of multitasking and interruptions [8, 12, 21]. Interruptions can be beneficial, for example, in gaining relevant information, addressing the task at-hand [21], or as a way to exert control over work by choosing when to respond to others [29]. However, some argue that interruptions can have a negative impact on work when they cause people to switch contexts or create redundant work [21], if they occur at inappropriate times [8], or if they lead users to forget their main task focus [9]. Evidence suggests that fragmented work patterns negatively impact work productivity [24].

Observation of information workers reveals that they switch tasks on average every three minutes [12]. Much switching concerns email: studies show with consistency that people spend about 23% of their time on email [8, 25], with an estimate that people check email about 36 times an hour [25]. This could be an overestimation, but even if halved, and if true, it would comprise a large component of multitasking. Further, people self-report that a high amount of email is associated with a high level of stress [2, 10].

Different theories have been proposed to explain how email creates overload for people. Managing the sheer volume of email is one factor [29], but the more time spent on email, the more likely it creates a feeling of overload [2]. Poor email management strategies also play a role [10, 29], as does the effort to keep track of separate email threads [3]. Recipients generally need to meet the task demands of the sender, which can exacerbate this sense of overload [25].

Despite the wide attention that email overload has received, it is still unclear to what extent email actually contributes to multitasking. Does email lead people to focus less on the task at-hand? In this paper, we address the following research questions related to email and multitasking:

- How is multitasking affected in the absence of email? Is multitasking fueled by email, or would multitasking occur at the same rate in today's information work climate without email use? Does email lead to the increased fragmentation of work?
- Though stress has been self-reported to correspond to email use, to date no study has ever *directly* measured the effect that email has on stress. Stress associated with email has been based on self-reports through surveys or logging [2, 10, 25]. Yet there may be biases in self-reports of stress—for example, in overestimating it. We therefore ask the question: how much stress does email use actually cause? We measure stress directly during *in situ* work using mobile wearable sensors.

There are several reasons why it is important to take an inverted perspective and investigate how work might change when email is removed. First, it enables us to understand whether it is possible to create an environment in which people can focus more closely on their tasks. Since people self-interrupt to check email often [19, 21,

29], would they be able to spend longer durations on tasks when email is not available and when keeping up-to-date with incoming email is no longer a concern? Ultimately, we are interested in providing support to avoid work fragmentation, given the negative consequences associated with this problem [24]. Second, we are interested in learning whether—and how much—stress might be reduced without email. While it is not realistic for an organization to eliminate email usage, this study can shed light on how email management and organizational email policies might be improved.

Our method to directly address the role of email in multitasking was to design an intervention in which multitasking is observed both *with* and *without* email. It is only by comparing a baseline condition (the status quo, i.e., typical email usage) with an experimental manipulation (the absence of email) that we can directly examine the effects email plays on multitasking and stress in the workplace.

RESEARCH SETTING

The study was conducted in a large scientific research organization located on the east coast of the United States. For the current study, participants were recruited by inviting them to information sessions. A total of 13 participants volunteered for the study (6 females, 7 males, mean age = 46). Additionally, 36 of their colleagues (13 females, 23 males) in their workplace social network volunteered to provide end-of-day surveys during the study. Our study was approved by institutional review boards at our home institutions and at the field site.

All of our participants were information workers whose job titles included chemical engineer, materials scientist, psychologist, biologist, food technologist, and research administrator; four of the 13 worked as managers or mentors with significant supervisory responsibilities. Their self-reported job characteristics revealed, on average (using a 5-point scale, where 5 was high), relatively high levels of creativity ($M = 4.5$, $SD = 0.52$), autonomy ($M = 4.3$, $SD = 0.9$), and day-to-day task variety ($M = 4.4$, $SD = 0.5$). All participants had some level of postsecondary education, and averaged employment in their current job for 8.4 years.

Methodology

Our study was a within-subjects design, with each participant taking part in a three-day baseline data collection phase and a five-day experimental (“No Email”) condition. In both of these conditions, we collected data using a combination of ethnographic methods and automatic, computer log and sensor-based data collection.

On the first day of the study, we conducted an initial semi-structured interview with each participant to ask about his or her existing multitasking and email usage strategies. After installing a custom window activity logging application on his or her computer and providing instruction about how to use the heart rate monitor, a researcher spent the rest of the day conducting an in-person ethnographic observation of a typical, “baseline” workday. We also

began recording activity in the office using our logging software to capture shifts in document and application windows as a measure of how often people were multitasking in their electronic work, a process that we repeated for two additional days (and sometimes more), to ensure that our system collected several days' worth of baseline data.

On the fourth day of the study, participants experienced the No Email experimental condition—complete email cutoff for a five-day period. During these days, we created a Microsoft Outlook email-processing rule that would automatically file away incoming messages without triggering any pop-up notifications. We also asked the participants to voluntarily refrain from sending work-related email. However, because so many participants used other facets of the Outlook software (e.g., contacts, the calendar, SharePoint shared folders), we allowed participants to use Outlook and access emails that had been received prior to the onset of the experimental condition.

We recorded activity in the office for all five of the No Email days using the window activity logging software. A researcher returned on the final day of the experimental condition to conduct a second day of ethnographic observation. At the conclusion of the study, we conducted a semi-structured interview in which we asked about the participant's activity management strategies and about their experiences of not having email available. Post-study interviews lasted about one hour.

Our use of ethnographic methods was intended to provide a rich corpus of data for understanding the complex actions in the workplace. To understand multitasking behavior *in situ*, we needed to capture details of process and content of our participants' workplace activities. An alternative technique, videotaping our participants, was not permitted by our field site. Thus, we used a "shadowing" observation technique similar to that used in previous time management and multitasking studies [12, 21, 22]. A researcher sat with the participant in his/her workspace and followed the individual, whenever possible, to meetings or other activities. The researcher recorded every action that the participant performed to the second, such as opening a computer application or making a phone call. Details about each event were also noted. All interactions with colleagues were documented, including details about the conversation topic, documents used (if possible) and persons involved. We conducted this in-depth observation for two days of the study—the first day of the Baseline condition and the last day of the No Email condition.

Our custom window activity logging application was designed to collect real-time data about our participants' multitasking behavior. This application was installed on each participant's computer workstation before we began data collection, and it ran for the entire duration of the study. The software recorded the frequency of switches between document or program windows where electronic

work is carried out (after [18, 23]). In order to gather more objective measures of stress and arousal, the participants wore an electronic heart rate monitor while working—the Garmin ForeRunner 301, consisting of a chest strap and wristwatch receiver—for the duration of the study, i.e., in both the Baseline and No Email conditions.

We administered survey instruments at the beginning and end of the study, as well as at the end of each day. Pre-study survey questions included a demographic questionnaire and a polychronicity preference instrument (IPV) [6], which measures the extent to which participants prefer to work in a polychronic or monochronic manner. At the end of each workday, we delivered several surveys electronically from our data collection software, including the NASA TLX workload scale [15].

Finally, in order to assess the impact of disconnecting a colleague from email, we asked members of the participants' workplace teams to serve as peripheral participants in the study. We asked these team members to complete short surveys at the end of each day about their own perceived productivity, their ability to get information needed to accomplish work on that particular day, and their success (or failure) in getting information that they needed from the main participants, given the changes in their accessibility via email.

RESULTS

Over the course of the study, we conducted nearly 137 hours of ethnographic observation. Our automated sensors captured over 25,000 window changes and recorded over 1.6 million sensor events over a total of more than 700 hours of data collection. The heart rate monitors provided readings of heart rate every few seconds; we received over 40,000 of these readings during the course of the study.

Sometimes illness, vacations, and technology failures interfered with our study schedule. When these incidents occurred, we rescheduled our informants so that they experienced email cut off for a period of five consecutive days. In some cases, this led to our extending Baseline or No Email data collections beyond the typical 8-day window.

We asked participants at the end of each day of the study if they considered that day to be "normal" in terms of the volume and type of work they did. We found no statistical difference for participants in the number of days judged to be normal between the Baseline and No Email conditions. Approximately 65% of study days were reported as being normal workdays.

Workplace Activity: Shadowing of Participants

We observed and classified a total of 5,643 activities carried out by our 13 participants over the course of our in-person shadowing sessions, comprising 71 hours of data collected in the Baseline condition and nearly 66 hours in the No Email condition.

Activity Type	Baseline		No Email	
	Mean	SD	Mean	SD
Out of office* (work-related)	412.32	938.14	1195.24	2048.88
Computing tasks	52.47	90.52	50.32	82.81
Physical tasks (e.g., reading, jotting notes)	41.06	75.55	56.55	69.86
Communication in the office (excl. email)	84.82	256.94	60.15	103.68
Email (new/filed)	40.65	60.71	36.94	64.85
Metawork*	21.41	28.04	29.14	41.76
Other tasks	56.12	205.58	31.33	54.50
Overall	74.81	375.37	102.85	510.81

Table 1. Means and SDs of the observed durations (in seconds) of types of activities, excluding personal breaks.

* = sig. difference between Baseline and No Email at $p < .05$.

In general, participants reacted well to being cut off from email. Typically, participants stayed connected with their colleagues during the No Email condition through a combination of face-to-face meetings, telephone calls, and by having team members notify them (mostly face-to-face) of critical emails sent to the entire work group or laboratory. Although participants checked email habitually in the Baseline condition, by the fifth day of email cutoff, we observed that participants rarely tried to check email.

The actions recorded from shadowing were categorized into *categories* of activities, as shown in Table 1. A three-way ANOVA of the *duration* of observed activities with condition, participant, and activity type as factors reveals a significant main effect of condition, $F(1, 12) = 6.881$, $p < .05$, indicating that, overall, participants spent longer in activities on average in the No Email condition than they did in the Baseline condition. We also found a significant main effect of activity type, $F(6, 76) = 14.301$, $p < .001$, and a significant interaction of condition by activity type, $F(6, 69) = 8.753$, $p < .001$, suggesting that our participants allocated their time differently across different kinds of activities when access to email was limited. We also observed significant interactions of condition by participant, $F(11, 95) = 3.432$, $p < .001$, and condition by activity type by participant, $F(60, 5474) = 4.849$, $p < .001$, suggesting that there were individual differences in how participants reacted to changes in email availability and in their strategies for multitasking in each of the conditions.

In order to better understand the effect of cutting off email on activities, we ran a series of paired t-tests on the mean durations that participants spent working in each type of activity. We found significant differences in just two of the activity types. First, participants spent significantly longer on out-of-office activities in the No Email condition compared to the Baseline condition: $t(12) = -3.001$, $p < .05$.

Second, we found that participants spent significantly more time carrying out metawork (i.e., activities not connected with any single project but associated with managing all of them [12]) in the No Email condition than they did in the Baseline condition: $t(12) = -2.558$, $p < .05$. This difference might be explained by the fact that coordination work, often carried out via email, is frequently interleaved with metawork activities; without email, this coordination work may be deferred, leading to larger contiguous blocks of metawork.

Surprisingly, the duration of time spent in each session reading, writing, or reviewing attachments to emails—either newly-arrived or those archived in the participants' stored folders—did not differ significantly between the two conditions. Although this is a counterintuitive finding since email was cut off, a potential explanation can be found in the data we collected about the *frequency* (i.e., the total number of activities observed) in which participants engaged in each category of activity in the different conditions. A three-way ANOVA of the *frequency* of switching observed activities yielded a significant main effect of activity type, $F(7, 73) = 28.526$, $p < .001$, as well as significant interactions of condition by activity type, $F(6, 60) = 2.412$, $p < .05$, and condition by participant, $F(11, 60) = 4.160$, $p < .001$. We also ran paired t-tests on these data to determine whether there were any differences in the frequencies at which participants switched activity types across the two conditions. The only activity type that showed statistically significant differences was the email activity; participants worked in their email client significantly less frequently in the No Email condition compared to the Baseline condition, $t(11) = 3.964$, $p < .01$. Thus, though participants used their email client less often when email was cut off, we found no difference between the amount of time they spent using Outlook in either condition (e.g., in the No Email condition, they read emails received prior to the study).

Multitasking Measures: Window Switches

Next, we looked at the sensor data that were collected from tracking computer window switches over the entire 8-day duration of the study. To measure differences in multitasking between the Baseline and No Email conditions, we looked at the duration and frequency of window switches. Table 2 shows, for each participant, the means and standard deviations of the durations (in seconds) that application and document windows were left open, as well as the frequency of window switches (in switches per hour) during each hour that our sensors collected data. We counted all window switches, including when auxiliary windows were invoked (e.g., reading a PDF attachment from a past email). Seven extreme outliers were removed from our set of over 25,000 data points.

For all but one participant, the mean window duration was longer during the No Email condition compared to Baseline. A paired t-test comparing each participant's

P	Baseline				No Email			
	Duration		Frequency		Duration		Frequency	
	M	SD	M	SD	M	SD	M	SD
1	76.4	466.7	36.2	34.3	106.1	621.6	12.7	21.2
2	72.6	329.7	27.2	26.0	214.0	729.9	9.1	14.1
3	79.4	450.1	39.2	33.5	121.9	536.2	25.4	20.8
4	53.2	166.9	53.9	34.5	109.8	322.7	24.6	17.7
5	133.8	554.8	17.5	18.5	216.6	882.3	8.2	13.1
6	55.3	275.9	44.2	32.7	83.4	285.0	24.1	23.3
7	67.4	397.9	45.1	33.1	115.7	596.9	25.8	28.1
8	100.6	402.1	26.7	23.0	156.8	821.5	16.2	41.5
9	78.8	369.9	40.1	26.1	181.6	658.1	9.0	12.2
10	53.8	181.0	47.5	29.5	198.4	828.1	16.2	25.2
11	130.5	421.9	23.4	18.8	180.7	560.5	17.5	17.1
12	99.4	400.7	25.5	24.1	126.8	441.9	24.1	17.2
13	62.3	438.2	42.7	33.3	56.7	156.4	30.6	32.0
M	75.5	394.3	37.1	31.4	131.9	568.1	18.2	23.5

Table 2. Mean and SD of window duration (in seconds) and frequency of window switches (switches/hour in which data were collected) for each participant.

window duration during the Baseline and No Email conditions showed that participants spent highly significantly longer times in a document or program window in the No Email condition: $t(12) = -5.00, p < .001$. Combining participants' data, an ANOVA with condition and participant as factors shows a highly significant difference between conditions: $F(1, 14) = 28.01, p < .0001$. There was no significant difference between participants: $F(12, 12) = 2.37, p > .05$. There was, however, a significant condition by participant interaction: $F(12, 25094) = 3.18, p < .0001$. Thus, the data show that there was a significant change in the length of time that participants' windows were active between conditions: in the No Email condition, participants had individual application windows open for a significantly longer duration before switching to another window, compared to those in the Baseline condition.

We also examined the frequency of window switches. Table 2 shows that all participants had a lower mean frequency of window switches in the No Email condition. A paired t-test comparing participants' frequencies in Baseline to No Email showed a highly significant difference: $t(12) = 6.50, p < .0001$. Thus, participants in the No Email condition switched their windows significantly less often than in the Baseline condition. Combining participants' data, an ANOVA showed a highly significant difference between Baseline and No Email: $F(1, 13) = 44.23, p < .0001$, with a significant difference between participants: $F(12, 12) = 3.14, p < .05$. There was also a significant condition by participant interaction: $F(12, 903) = 1.97, p < .05$. Thus, overall, the window logging data show that participants in the No Email condition had individual application and document windows active for longer durations and switched between them less often than they did in the Baseline condition, when email was available.

Email and Stress: Heart Rate Monitoring

We also directly measured participants' level of stress when working with and without email through the use of heart

rate monitors. Participants wore the heart rate monitors full time while at work. Heart rate variability (HRV) is widely used as an indicator of mental stress (see [1, 4, 5] for reviews). The lower the measure of HRV, the higher the amount of stress that an individual experiences. The correlation between stress and HRV is high; as arousal increases, HRV decreases. The body responds to stressful circumstances by regulating itself: the sympathetic nervous system is very good at responding to stress. Similarly, when people are not experiencing stress, HRV is higher, as the heart rate fluctuates more, i.e., the body is not regulating itself. A lowering of HRV has been associated with other factors related to stress (e.g., depression [14] and anxiety [31]). HRV has been used to measure a variety of phenomena, including stress during computer work [17].

A recommended measure of overall HRV is the standard deviation of heart periods [5]. Our goal was to measure study participants' stress during the Baseline and No Email conditions and we did so by measuring HRV continually as participants went about their normal work. Due to technical difficulties, we were only able to capture data across both the Baseline and No Email conditions from seven of our participants. Table 3 shows the number of days for these participants in which heart rate data were captured. In post-study interviews, no one reported that wearing the heart rate monitor was obtrusive or that it affected their behavior. Nearly all participants reported that once they put the chest strap on, they forgot about it. One participant wore the monitor home once because she forgot that she was wearing it. Another participant reported that he tended to "sit back more" but did not believe it changed his behavior. A third person reported that it was "a bit annoying," but she wore it on all of the study days except one.

We computed the HRV using the standard deviation of the recorded heart rate, which is the standard way to measure HRV [5]. Table 3 shows measures averaged for each participant and for each condition over all the days that data were collected. A paired comparisons t-test between the Baseline and No Email conditions shows a very strong trend that people in Baseline had lower HRV (i.e., higher

Subj.	Baseline			No email		
	# days	Mean	SD	# days	Mean	SD
2	6	76.35	8.43	5	79.29	10.60
3	4	88.99	9.82	3	93.70	9.85
4	3	71.31	7.06	3	76.07	5.36
5	5	74.92	23.72	5	75.61	25.93
6	3	95.88	18.80	8	100.00	23.39
8	2	77.15	8.75	7	78.99	13.03
11	3	62.26	9.40	4	67.22	18.22
Total	26	77.03	16.173	35	80.39	18.36

Table 3. Mean and SD of heart rate monitor data and number of days that data were captured for each condition.

stress) than those in No Email (Mean difference = -2.926 , $SD = 3.425$, $t(6) = -2.260$, $p = .065$). Levene's test conducted on the comparison of the standard deviations of all Baseline data with all No Email data shows this difference to be highly significant: $SD(\text{Baseline}) = 16.17$, $SD(\text{No Email}) = 18.36$, $F(1, 40409) = 170.86$, $p < .0001$. These results indicate that participants experienced less stress when their email was cut off than in the baseline condition when they had email access.

An ANOVA conducted on the mean heart rate with Condition and Participant as factors shows that the measure was significantly less in Baseline than in the No Email condition: $F(1, 40409) = 33.40$, $p < .001$. There was also a significant difference between participants, $F(6, 40409) = 206.34$, $p < .0001$, and a significant interaction of condition by participant, $F(6, 40409) = 16.30$, $p < .0001$. Thus, mean heart rate was higher in the No Email condition. While there could be a number of explanations for this result, heart rate generally increases with activity. This notion is consistent with our observations, which showed that without email, participants engaged in more "Out of office" activities (see Table 1).

Attitudes of Multitasking and Email: Surveys

Surveys were deployed to help us understand whether immersion in an "email free" work environment might be affected by—or influence—participants' attitudes about multitasking and feelings of productivity, time pressure, and frustration. We asked participants at the beginning of the study questions drawn from the Inventory of Polychronic Values (IPV), an instrument designed to assess *the extent to which people in a culture: (1) prefer to be engaged in two or more tasks simultaneously; and (2) believe that their preference is the best way to do things* [6].

Relative to the results reported by Bluedorn et al. [6], four out of 13 participants were categorized as having a high preference for polychronicity and nine participants measured an average preference for polychronicity. There was no significant relationship between polychronicity preference scores and mean window durations in either the Baseline or No Email conditions.

At the end of each day of the study, participants completed the NASA TLX workload assessment [15], which measures mental, physical, and temporal demands, as well as performance, effort, and frustration. An ANOVA conducted on participants' responses between the Baseline and No Email conditions showed no significant differences. These findings suggest that foregoing the use of email at work does not fundamentally change the subjective workload that a person experiences—in either direction.

Colleagues' Perspectives: End-of-Day Self-Reports

A person's availability via email has the potential to impact not only their own multitasking and stress levels, but also to affect the ability of their colleagues to find information they need to collaborate and to delegate tasks. For each of our study participants, we recruited a group of 2–7 of that

person's closest team members to answer a short series of survey questions at the end of each day of the study. These questions combined general queries about the success and stress level of the colleagues' day (e.g., "Rate the following statement: I was able to get the information I needed to conduct my work today" and "How productive do you think you were today?") and a question specifically geared to determining the impact of the main participant's availability or unavailability via email ("Rate the following statement: It was easy for me to reach [name] to get information I needed from [him/her]").

An ANOVA showed no significant difference in team members' responses between the Baseline and No Email conditions for these questions. However, a trend approaching statistical significance revealed that team members agreed more strongly with the statement "I was able to get the information I needed to conduct my work today" in the Baseline condition ($M = 4.53$, $SD = 0.28$) than in the No Email condition ($M = 3.71$, $SD = 0.26$), $F(1, 47) = 3.221$, $p < .08$.

QUALITATIVE DATA ANALYSIS

How did our informants feel when their email was cut off for five days? The post-study interview data was open-coded and themes were identified. Not surprisingly, nearly all informants viewed email as "*double-edged*," having pros and cons. Attitudes towards email could be categorized in two ways. To two informants, they viewed email primarily as a communication tool in their work—these people missed email the most when it was cut off. The second category—the rest of the informants—expressed an attitude that email was primarily a burden. A common reason expressed by this latter group was due to the volume, e.g.:

My work has become how to manage email.

I have so many emails, I don't even read them.

With email, it's a train wreck... you can't look away from it.

One informant's attitude was extreme:

[Email is] an annoyance, a giant to-do list. I got to the point where, being overwhelmed, I gave up.... That would be nirvana—to tell everyone I'm wiping out my email.... It's ruining my life, it's interfering with my happiness.

Only one informant considered herself addicted to email. She explained that she takes her BlackBerry on vacation but then locks it in the hotel safe to keep from checking email. One informant explained she was not addicted but would not want to live without it. Still another admitted that at times he felt addicted to email.

Lack of Agency

Another reason why informants viewed email as a burden was that they felt that it affected their agency to work. About half of the informants described that they felt like they were not in control of their email, and consequently not in control of their work. Attitudes were expressed as:

It ruled my life—that made me feel depressed, and now I feel liberated [without email]...too much headache trying to keep on top of everything.

I let the sound of the bell and the pop-ups rule my life.

[When email was cut off]: *Felt it was under my control.*

It prompts me. When you come back, it's waiting.

In contrast, when asked how they felt about working without email, nearly all informants described that their pace was more relaxed. One informant described he felt “liberated”; another informant expressed the biggest benefit as “peace”; still another described it as “refreshing.”

Email, Communication, and Relationships

A theme that emerged was that when email was cut off, face-to-face interactions with other colleagues in the workplace increased. All informants reported that with email cut off, they interacted with people more, both face-to-face and by phone, whereas they would usually send emails instead. They viewed this change as a benefit. Nearly all informants described how they walked around the workplace more to visit their colleagues for face-to-face interactions in the No Email condition; some even walked to other buildings on the campus. Some visits to colleagues were by choice, as opposed to placing a telephone call².

The lack of access to email enabled the informants to reflect more deeply on how email affects their relationships with their colleagues. The informants expressed that during the time of email cut off, they became aware that the use of email hindered their work relationships. Some representative comments that express this idea were:

...Email can be a superficial blanket that distances you from real relationships where you're really working together.

I socialize and the social aspect became that much greater.

I was surprised at how much all that human interaction came in to fill the vacuum [i.e., when having no email].

[Working without email] *helps with one-on-one relationships.*

Email is easier, but getting up and walking around, it's a lot easier to talk face-to-face. You can pick up more vibes of the relationship thing that you can't do with email.

Focus

Our quantitative results showed that in the No Email condition, people switched tasks less and spent longer durations on each window screen before switching. The interview data corroborate this result. A common theme that was expressed by nearly all informants was that during the time that email was cut off, they were able to spend longer periods of time on a task and focus more intently on their work. One informant described that during the study,

he learned that email was his main source of self-distraction. The word “focus” was found often throughout our interview data. Typical comments included:

It gave me more focus.

It gave me time to think about [work] more.

I was able to spend time actually doing tasks that had to be done.... It was nice to be able to sit and work on a manuscript for the whole morning.

When I didn't have email, multitasking, I had three projects done. I was more focused.

[I] *wasn't distracted by checking email. It was nice. I was able to plan more what I was doing for a chunk of time.*

I was writing a report, and I could focus on the report.

Only one person told us that she was surprised that, despite expecting to be able to accomplish a larger number of projects in the No Email condition, she did not.

Feeling Cut Off

The biggest disadvantage expressed by the informants when they did not have email was that they felt “cut off.” Two informants did not report feeling cut off (one reported that he did not miss anyone); one informant felt cut off “a little bit” but was “OK” with it. Only one informant mentioned from whom she felt cut off (off-site customers). About half the informants described it as a general sense of isolation:

You have that sense that there's something really important, there's a deadline that you missed... not knowing.

The hardest thing was not being sure what I missed.

I felt disconnected for sure. When email is down, it makes me crazy. I don't feel as productive...it was difficult.

Yes—hands down—it isolates you as the one person who's not “plugged in.”

There was a little uneasiness...felt I was missing something.

I didn't like knowing that information was coming or not 'cause there's the expectation that you're on email.

Thus, though most informants reported feeling cut off from others, this feeling seemed to be grounded in a fear that they were potentially missing out on information being exchanged within the organization.

As a result of not using email in the workplace, the informants could describe their actual experiences of how email affects work, as opposed to their perceptions. The interview data revealed that there were various ways that email was reported to be burdensome. First, the social norm that surrounds email use is primarily what causes it to be a burden. The informants commonly expressed that there is a norm or expectation that the email recipient will respond to an email quickly. For example, one informant comes into work two hours later than her colleagues. She described how her colleagues, who arrived at work and sent out emails two hours prior, expect an answer to their emails as soon as she arrives. Second, email is a burden due to the

² In our shadowing observation, we could not always follow informants when they left the office; the activity of interacting with others outside the office is characterized as “Out of office” in Table 1.

sheer volume of email that people receive. The informants commonly reported not being able to keep up with their email. They referred to important emails that get lost in the flood of incoming messages. Third, the informants admit that they lack self-control to not check email regularly. In some cases, this lack of self-control translates into a lack of agency in the workplace, as two informants described: a “lack of control” and that it “rules their life.” Last, email is a burden when it is used as a channel for delegating work. Aside from the two informants who viewed email primarily as a communication tool, to the other informants, it was a channel for delegating tasks to others. One informant’s experience is an illustration—this informant receives “taskers” from his superiors. These refer to tasks that he needs to do immediately. As a lab scientist, this interferes with his ability to set up and run experiments without interruption. When his email was cut off, the taskers suddenly stopped. Though his superiors could have called him on the phone or walked down the hall to delegate the task to him, this did not happen. This experience led him to believe that the taskers he had been receiving by email were either not important or that the senders had taken initiative to find the information themselves when he was off email.

DISCUSSION

We set out to discover whether email was a significant component of multitasking behavior, and whether, by removing email, people would focus more on their tasks and multitask less. Our results show that without email, people did multitask less and had a longer task focus, as measured by a longer duration of time spent working in each application window and a lower frequency of shifting between windows. In other words, our data show that email usage leads to more work fragmentation. Perhaps this is not surprising, as other studies have shown how often people check email [19, 25]. Our study confirms, that without email, multitasking would be reduced. This raises a number of other questions, such as: how much information sent through email is actually necessary or desirable for work?

We also directly measured whether email causes stress. We found a strong trend that stress, as measured by HRV, was lower when email was removed. We expect that this result would achieve significance with more subjects. If workplace stress is detrimental to health, as some research suggests [16], then our results may even suggest that email could contribute to workplace health problems by raising stress levels. This is a topic for further research.

It is possible that the out-of-office activity could have affected HRV. Though HRV is reported higher in athletes [7] and in older adults doing aerobic activity [27], there is little data about the relationship between HRV and physical activity or exercise in the general population. In our study, any activity (e.g., walking to meetings) was a random effect variable—it occurred in both conditions of our study, and is therefore an unlikely contributor to the trend that we observed between conditions.

It is difficult to disentangle the different sources of stress in the workplace, so we can only speculate as to whether it is the volume of email, social expectations and organizational conventions associated with email, or the symbolism of email as a delegator of work [2] that lead to the increase in stress that we observed. It is noteworthy that we found stress levels to change within a period of just five days without email. This suggests that short “vacations” from email may be sufficient to reduce stress in the workplace. At the same time, the higher mean heart rate that we found without email use is consistent with both our observations and our interviews, which show that without email, people take more frequent work breaks, during which they move around the workplace more. This would suggest that not only might reducing email reduce stress, but that reducing use of email may even be good for health. Of course, further research would be needed to examine this hypothesis. Overall, our results suggest that the reduction of email needs to be taken seriously by organizations and they raise a number of potentially interesting issues for future study.

Email and Non-mediated Interaction

One of the interesting findings that emerged from the interview data was that not having email led to more face-to-face interaction. On the whole, the informants reported that they enjoyed their social life at work with their colleagues more when email was cut off. Combined with lower stress levels and the reports of being more relaxed, this leads us to question more broadly how email is affecting workplace relationships.

Interestingly, the colleagues in the participants’ work groups did not report detrimental effects when their colleagues were off email. Aside from reporting that it was harder to get information from their colleague (which was expected), their satisfaction, productivity, and stress levels were not affected. As a result, we might hypothesize that when a person upon whom one relies for information becomes unavailable for a period of time, this will increase the self-initiative of the information seeker to find the information or to solve the problem on their own.

The Pace of Work

Our findings suggest that email speeds up the pace of work. Participants switched between windows more often, and the amount of time they spent in any one window before moving on was shorter with email. At the same time, from the interviews, nearly all informants reported that email creates expectations that the receiver will respond quickly. When we combine our quantitative and qualitative results, we see support for the idea that email drives a cycle of working at a faster pace. We cannot say whether this is positive or negative for organizations; our study results do not address whether a faster work pace is associated with higher productivity or efficiency. What we can say from our data is that the study participants overall preferred a slower pace of work based on their reactions to work life without

email. Perhaps this is best expressed by the informant who described not having email as allowing him to work at “a pace not dictated by electrons.”

Implications for Organizations

Our results suggest several implications for organizations in alleviating the burden of email on employees. First, our results reinforce some existing recommendations that reading email in batches might be efficacious [26]. Our informants were off of email for five days. In the interviews, most of the informants described that they dreaded reading their email when they concluded participation in the study. However, the process of catching up was not as bad as they anticipated. One informant, for example, said that when he returned to email, he read through his inbox quickly and learned a strategy of eliminating emails based on their subject header. He claimed that this took far less time than handling emails by checking them regularly throughout the day. This finding illustrates a contrast to the survey responses reported by Dabbish and Kraut [10]; our informants reported feeling *less* overloaded with restricted email use. These differences might be explained by the evolution of email management strategies over the last several years, the specific culture of email usage in the organization we studied, or the fact that we were examining email usage in the broader context of multitasking and information work. While we do not suggest that reading email should be done in batches of several days, organizations could consider experimenting with establishing practices of exchanging email—at least within particular work groups—at certain intervals, such as first thing in the morning, after lunch, and in the evening. Organizations could also try deferring informational emails to a pull-oriented channel (e.g., an intranet website or RSS feed), rather than sending email “blasts” that necessitate action by every employee.

One of our intriguing results was that without email, our informants consistently reported feeling relaxed and more focused. This suggests that an organization should consider the immaterial benefits for workers in restricting, filtering, or actively managing the delivery of email.

Are we suggesting that organizations cut off email? Absolutely not. We did learn a great deal from this study, as did our participants. For example, informants reported that when someone needed to reach them and email was not available, they often used an alternative means. Perhaps if communication is dispersed within an organization across various media, e.g., IM, telephone, or face-to-face, it would create less email traffic and may lower stress. Of course, dispersed communication channels lead to other problems such as not knowing which means to use to reach someone. This is a topic of ongoing research.

Limitations

Although we studied a relatively small group of 13 participants (and surveyed their immediate colleagues), we do not feel that this factor adversely affected the validity of

our findings, for two main reasons. First, this participant size is consistent with previous, observation-only studies of workplace multitasking (cf. [12]). Second, our combination of qualitative and quantitative data collection techniques provided an enormous amount of data from each participant over almost two weeks of authentic, *in situ* work.

One of the main limitations of the study is that we collected data at only a single field site, a decision that we made because of these workers’ willingness to commit to a demanding study schedule, including observation and the use of heart rate recording devices, and the support that we received from the field site administrators in allowing us to ask employees to forego use of email for an entire week. Even within this organization, we may have unintentionally encountered some bias due to participant self-selection, since only a portion of those people who voluntarily attended a study information session consented to be in the study. Thus, our participants may have self-selected on the basis of their attitudes toward their email workload, concern with multitasking in the workplace, or for some other reason. From our initial interviews, we know that most participants considered email to be a burden, at least some of the time. We are also aware that some potential participants excluded themselves from the study because their jobs were solely focused on responding to email. We would strongly advocate that similar studies be run in a variety of different work contexts to help validate the findings with information workers that may have different practices and different relationships with the use of email.

We also encountered some technical difficulties with the heart rate monitors that prevented us from capturing data from all participants. However, our findings show a strong trend that would very likely reach significance with additional participants.

CONCLUSIONS

Our study has shown that there are benefits to not being continually connected by email. Without email, our informants focused longer on their tasks, multitasked less, and had lower stress. It is an open question to what extent the effects we found in our study might be sustainable. How the benefits of reduced email usage might outweigh the known benefits of email in reaching larger numbers of people rapidly with information is not clear. What our study suggests is that the tradeoffs among email usage, work pace, stress, and collaboration need to be more closely explored. There will always be new “zombies” lurking with advances in information technology, and we must continue to be vigilant in assessing the human costs that are incurred when these advances are adopted in the workplace.

ACKNOWLEDGMENTS

This work was supported by the National Science Foundation under award CNS-0937060 to the Computing Research Association for the Computing Innovation Fellows Project, as well as by the U.S. Army Natick R, D & E Center. We would like to thank the members of the executive steering

committee at our field site for their support of our study and our informants for their time (and patience).

REFERENCES

1. Acharya, U.R., Joseph, K.P., Kannathal, N., Lim, C.M., and Suri, J.S. Heart rate variability: A review. *Medical & Bio Engineering & Comp* 44, 12 (2006), 1031–1051.
2. Barley, S., Myerson, D., and Grodel, S. E-mail as a source and symbol of stress. *Organization Science* 22, 4 (2011), 887–906.
3. Bellotti, V., Ducheneaut, N., Howard, M., Smith, I., and Grinter, R.E. Quality versus quantity: E-mail-centric task management and its relation with overload. *Human-Computer Interaction* 20, 1 (2005), 89–138.
4. Berntson, G.G. and Cacioppo, J.T. Heart rate variability: Stress and psychiatric conditions. In M. Malik and A.J. Camm (Eds.), *Dynamic Electrocardiography*, Blackwell Publishing, Oxford, UK, 2007.
5. Berntson, G., Bigger, J., Eckberg, D., Grossman, P., Kaufmann, P., Malik, M., Nagaraja, H., Porges, S., Saul, J., Stone, P., and van der Molen, M. Heart rate variability: Origins, methods, and interpretive caveats. *Psychophysiology* 34, 6 (1997), 623–648.
6. Bluedorn, A., Kalliath, T., Strube, M., and Martin, G. Polychronicity and the Inventory of Polychronic Values (IPV): The development of an instrument to measure a fundamental dimension of organizational culture. *J of Managerial Psychology* 14, 3/4 (1999), 205–231.
7. Boutcher, S.H., Nugent, F.W., McLaren, P.F., and Weltman, A.L. Heart period variability of trained and untrained men at rest and during mental challenge. *Psychophysiology* 35, 1 (1998), 16–22.
8. Czerwinski, M., Horvitz, E., and Wilhite, S. A diary study of task switching and interruptions. In *Proc. CHI 2004*, ACM Press (2004), 175–182.
9. Cutrell, E., Czerwinski, M., and Horvitz, E. Notification, disruption, and memory: Effects of messaging interruptions on memory and performance. In *Proc. INTERACT 2001*, IOS Press (2001), 263–269.
10. Dabbish, L.A. and Kraut, R.E. Email overload at work: An analysis of factors associated with email strain. In *Proc. CSCW 2006*, ACM Press (2006), 431–440.
11. Fogarty, J., Hudson, S.E., Atkeson, C.G., Avrahami, D., Forlizzi, J., Kiesler, S., Lee, J.C., and Yang, J. Predicting human interruptibility with sensors. *ACM Trans. Computer-Human Interaction* 12, 1 (2005), 119–146.
12. González, V.M. and Mark, G. “Constant, constant, multitasking craziness”: Managing multiple working spheres. In *Proc. CHI 2004*, ACM Press (2004), 113–120.
13. González, V.M., Nardi, B., and Mark, G. Ensembles: Understanding the instantiation of activities. *Information Tech & People* 22, 2 (2009), 109–131.
14. Gorman, J.M. and Sloan, R.P. Heart rate variability in depressive and anxiety disorders. *American Heart Journal* 140, 4, Part B (2000), 77–83.
15. Hart, S.G. and Staveland, L.E. Development of NASA-TLX (Task Load Index): Results of empirical and theoretical research. In P.A. Hancock and N. Meshkati (Eds.), *Human Mental Workload*. North-Holland, Amsterdam (1988), 239–250.
16. Hewlett, S.A. and Luce, C.B. Extreme jobs: The dangerous allure of the 70-hour workweek. *Harvard Business Review* 84, 12 (2006), 49–59, 162.
17. Hjortskov, N., Rissén, D., Blangsted, A., Fallentin, N., Lundberg, U., and Søgaard, K. The effect of mental stress on heart rate variability and blood pressure during computer work. *Eur J of Appl Phys* 92, 1–2 (2004), 84–89.
18. Hutchings, D.R., Smith, G., Meyers, B., Czerwinski, M., and Robertson, G. Display space usage and window management operation comparisons between single monitor and multiple monitor users. In *Proc. AVI 2004*, ACM Press (2004), 32–39.
19. Jackson, T., Dawson, R., and Wilson, D. Reducing the effect of email interruptions on employees. *International J of Information Management* 23, 1 (2003), 55–65.
20. Klosterman, C. My zombie, myself: Why modern life feels rather undead. *The New York Times*, Dec. 3, 2010.
21. Mark, G., González, V., and Harris, J. No task left behind? Examining the nature of fragmented work. In *Proc. CHI 2005*, ACM Press (2005), 321–330.
22. Mintzberg, H. Structured observation as a method to study managerial work. *J Mgt Stud* 7, 1 (1970), 87–104.
23. Nair, R., Volda, S., and Mynatt, E.D. Frequency-based detection of task switches. In *Proc. HCI 2005*. Springer (2005), 94–99.
24. Perlow, L.A. The time famine: Towards a sociology of work time. *Admin Sci Quarterly* 44, 1 (1999), 57–81.
25. Renaud, K., Ramsay, J., and Hair, M. “You’ve got e-mail!” ... shall I deal with it now? Electronic mail from the recipient's perspective. *IJHCI* 21, 3 (2006), 313–332.
26. Robbins, S. Tips for mastering e-mail overload. *Harvard Business School Working Knowledge* (2004, Oct 25). <http://hbswk.hbs.edu/archive/4438.html>.
27. Stein, P.K., Ehsani, A.A., Domitrovich, P.P., Kleiger, R.E., and Rottman, J.N. Effect of exercise training on heart rate variability in healthy older adults. *American Heart Journal* 138, 3 (1999), 567–576.
28. Turkle, S. *Alone Together*. MIT Press, Cambridge, MA, 2010.
29. Wacjman, J. and Rose, E. Constant connectivity: Rethinking interruptions at work. *Organization Studies* 32, 7 (2011), 941–961.
30. Whittaker, S., and Sidner, C. Email overload: Exploring personal information management of email. In *Proc. CHI 1996*, ACM Press (1996), 276–283.
31. Yeragani, V.K., Sobolewski, E., Igel, G., Johnson, C., Jampala, V.C., Kay, J., Hillman, N., Yeragani, S., and Vempati, S. Decreased heart-period variability in patients with panic disorder: A study of Holter ECG records. *Psychiatry Research* 78, 1–2 (1998), 89–99.